

Argonne National Laboratory HEP Theory Group

Overview of the Group Activities

C.E.M. Wagner

Argonne National Laboratory

KICP and EFI, University of Chicago

HEP Division Retreat, December 14, 2010

Composition of the Group

- Theory Group has currently seven staff members:

E. Berger	(Collider physics, QCD, BSM)
G. Bodwin	(QCD, Quarkonium physics)
R. Boughezal	(Collider Physics, QCD)
I. Low	(Collider Physics, BSM, Cosmology; joint with NW)
F. Petriello	(Collider Physics, QCD, BSM; joint with NW)
C. Wagner	(Collider Physics, BSM, Cosmology; joint with UofC)
C. Zchos	(Abstract Physics)

Postdocs and Students

Postdoctoral Fellows

Qing-Hong Cao (brought by Berger/Rosner ANL/UoC JTI funds)

Jamie Gainer (joint with NW)

Seth Quackenbush

Pedro Schwaller (joint with UIC)

Gabe Shaughnessy (joint with NW)

Students

Patrick Draper (Milikan Fellowship, Ph.D in 2011, Wagner's Chicago student)

Wei Chih Huang (Low's Northwestern student)

Ran Huo (Ph.D. in 2013, Wagner's Chicago student)

Activities

- Theory group has been very strong in the areas related to phenomenology of particle physics, which are our main research priority : Collider physics, QCD, Higgs physics, heavy quarkonia and beyond the Standard Model phenomenology.
- The group has also contributed relevantly to fundamental physics and to non-perturbative field theory.
- The group has also produced relevant articles in the interface of particle physics and cosmology, in particular on the questions of dark-matter and baryogenesis.

New Appointments

- Frank Petriello and Radja Boughezal have joined the group this year, and they are expected to considerably strengthen our collider physics activities.
- Radja has successfully proposed a candidate for a Director Fellowship, Markus Schulze, who has been doing interesting work on collider physics, for instance a NLO calculation of top production at hadron colliders.
- New joint postdoc with UIC, Pedro Schwaller, joined us. Expert on collider and BSM physics. Ongoing search for a postdoc joint with IIT.
- Salman Habib and Katrin Heitmann will also join the Division and they will be part of a theoretical cosmology computational group. They were hired as part of a Laboratory initiative to build national leadership in computational science.
- Salman and Katrin will be associated with the Theory Group, but supported for three years by LDRD funds

Postdocs

- The HEP Theory Group has been very successful in the supervision of postdocs.
- Most of the recent Argonne postdocs have found excellent positions and carried successful careers after their stay at Argonne
- Notable recent cases are
Csaba Balazs, John Campbell, Cheng-Wei Chiang, Ayres Freitas, Jay Hubisz, David E. Kaplan, Michael Klasen, Jungil Lee, Irina Mocioiu, Chris Jackson, Pavel Nadolsky, Geraldine Servant, Zack Sullivan and Tim Tait
- Recent students, supported by Argonne, have also had successful careers : David Morrissey is now a permanent staff at TRIUMF and Anibal Medina is a postdoc at UofC, Davis

Research Activities

Ed Berger

Ed's focus has been on collider phenomenology pertinent to the LHC and Tevatron colliders. He has recently published work on

- (1) Higgs boson production dynamics and decays,
- (2) The exploration of beyond-the-standard model exotic states that decay to pairs of top quarks, as well as on
- (3) Standard model QCD phenomena such as double parton scattering, and SM sources of isolated di-leptons and tri-leptons that are backgrounds for new physics searches.
- (4) Ed's long-standing interest in parton distribution function (PDF) analyses culminated recently in a new paper on the constraints on color-octet fermions (gluinos) from a global PDF analysis.

Much of Ed's research is done in collaboration with current and former Argonne postdoctoral associates.

Geoff Bodwin

Geoff's recent research has mainly focused on two areas:

(1) Proofs of QCD factorization theorems

(2) Quarkonium physics.

(1) Factorization theorems are at the heart of all predictions in perturbative QCD. Geoff and collaborators have recently proved factorization theorems for exclusive quarkonium production in B-meson decays and in e^+e^- annihilation. They also found that existing proofs of factorization theorems contain a loophole involving the treatment of collinear gluons with very low energy, and they have devised new methods of proof to plug that loophole.

(2) Much of Geoff's recent work on quarkonium physics has been aimed at improving theoretical predictions of quarkonium production processes through calculations of corrections of higher order in α_s and of higher order in the heavy-quark velocity v .

Ian Low

(1) Ian has been studying ways to reveal the identity of the Higgs boson at the Large Hadron Collider (LHC) in two ways : One is to understand the infrared identity of the Higgs, as given by the spin, CP, and electroweak quantum numbers, while the other direction seeks to infer the ultraviolet identity of the Higgs, which is related to the quantum stability of the Higgs mass parameter as well as whether the Higgs is a composite particle at the TeV scale.

(2) The other direction of Ian's research effort is to understand the nature of the dark matter by confronting theories with experimental data. Two different approaches are proposed: the top-down approach considers models of dark matter which could give rise to the observed anomalies, while the bottom-up approach studies correlations among different sets of experimental data in a model-independent fashion.

Carlos Wagner

Carlos's main focus of activity has been Higgs and beyond the Standard Model physics, the questions of Dark Matter and the baryon antibaryon asymmetry.

Recently, he has published work on

- (1) The Higgs reach of an extended run of the Tevatron collider and its comparison with an early LHC run,
- (2) The possible interpretation of the observed top forward backward asymmetry at the Tevatron.
- (3) Wagner and collaborators proposed a new method, based on Renormalization group invariants, to extract information on high energy physics based on low energy LHC measurements in supersymmetric theories;
- (4) worked on a new consistent framework that could lead to the explanation of the possible direct Dark Matter cross section signatures observed at the DAMA/COGENT experiments.

Cosmas Zachos

Cosmas has been recently working on Renormalization Group Functional Equations

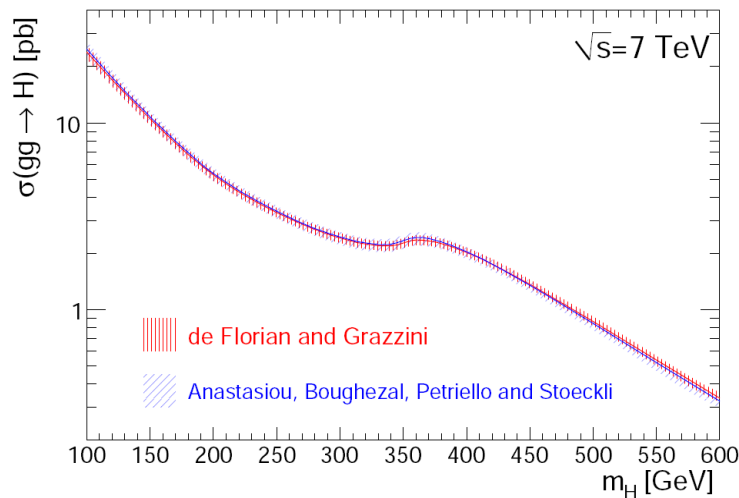
CZ has been working on hitherto unappreciated subtleties in the finite Renormalization Group equation of Gell-Mann and Low.

(1) With T Curtright, he has uncovered its functional structure and utilized it to analyze lattice gauge theory improvements of its solutions.

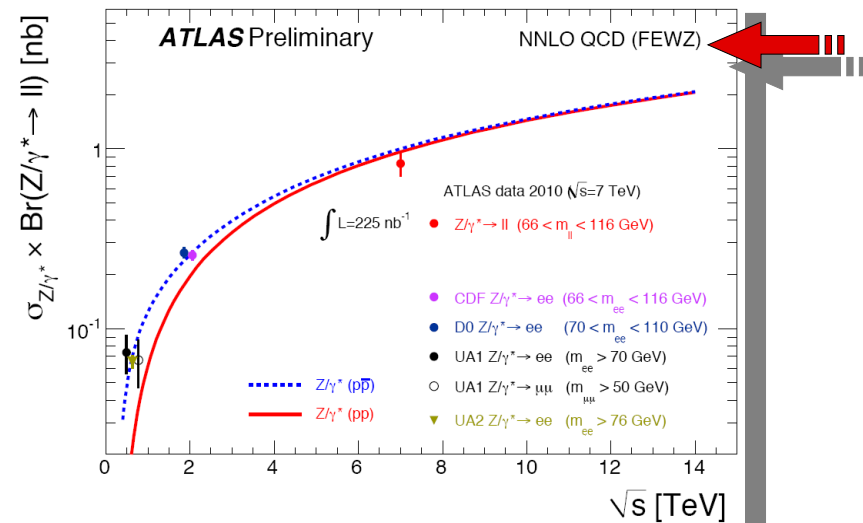
(2) They have also developed novel mathematical techniques for solving these equations, modeled on simple systems, which led to new, unexpected logical possibilities for renormalization trajectories, including limit cycles.

QCD @ the LHC (Radja Boughezal & Frank Petriello)

- Our focus is on understanding the structure of QCD to higher orders in perturbation theory to enable precision predictions for collider physics observables.
- Representative work includes the calculation of the Higgs production cross sections used by the Tevatron collaborations in setting their exclusion limits, and the development of the simulation code **FEWZ** which describes W and Z production through NNLO in QCD and is used by ATLAS in their analyses.



CERN Yellow Report, to appear



ANL-HEP-PR-10-60: by Petriello, Quackenbush and collaborators

- Future research will focus on devising new methods to allow for the calculation of higher-multiplicity processes such as V+jet through NNLO in perturbation theory (ANL-HEP-PR-10-58 by Boughezal and collaborators).

Conclusions

- Theory Group has been productive in a very broad range of subjects, including collider, quarkonia and beyond the Standard Model physics, as well as more formal subjects.
- The group has close ties with most **nearby Universities** as well as other **research institutions** in the Chicago area, including Univ. of Chicago, Northwestern, UIC, IIT and Fermilab.
- It has been extremely successful in the supervision of postdocs and students and has organized several well attended workshops and conferences
- We have **strengthened our collider physics activities**. Our goal has been to attract broad particle physics phenomenologists, who can make an impact in the coming LHC era and collaborate efficiently with local experimenters. **Frank Petriello and Radja Boughezal** fulfill such a goal.
- Appointments of **Habib and Heitmann** open a new opportunity for the Division and the Theory Group in connection with computational science and cosmology.